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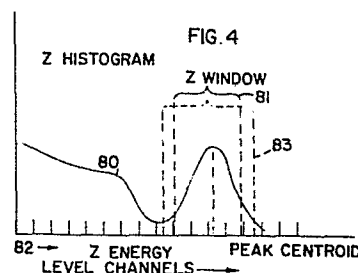
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54 **Energy window selection for a radiation signal processing system.**

57 An improved method and apparatus for energy window selection in a radiation signal processing system comprises flooding the camera with a substantially uniform radiation; determining the apparent spatial position and energy level of detected radiation events; determining corrected spatial positions of the detected radiation events; determining the energy level distribution of the detected radiation events in each of a plurality of uniform corrected spatial elements; and determining an energy level acceptance window in each distribution such that the number of events accepted in each element is substantially the same. A preferred embodiment includes obtaining energy level histograms corresponding to corrected spatial elements and determining a standard count of radiation events to be accepted by each corrected spatial element in response to a flood image. The energy window of each corrected spatial element is then adapted to cause each to accept the standard count of radiation events in response to the flood image whereby greater uniformity of image may be accomplished in the imaging process. The window values are stored as a function of apparent position.



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ENERGY WINDOW SELECTION FOR A RADIATION SIGNAL
PROCESSING SYSTEM

Technical Field of the Invention

5 This invention relates to the field of nuclear
imaging systems in medicine and more particularly to the
processing of signals from gamma ray cameras.

Background of the Invention

10 Nuclear medicine is one of the most rapidly
developing fields of clinical investigation. The term
deriving from its origin in nuclear physics involves
administration by injection into a vein of a small dose of
radioisotope (a radioactive substance emitting gamma
rays). The bloodstream distributes the dose throughout
the body and a suitably sensitive transducer records a
15 history of this distribution.

Areas of the body having high "uptake" of the
isotope or a rich blood supply show up as bright or highly
illuminating sources while conversely those of low "up-
take" or blood supply appear dark. In this manner any
20 portion of the body or specific organ may be subjected to
clinical investigation in a safe, reliable and non-
invasive manner.

The most frequently employed nuclear investiga-
tion device is a radiation transducer having a scintilla-
25 tion crystal (i.e. one that emits light photons propor-
tionately to received radiation energy quanta). The light
photons are detected by a plurality of phototubes in close
optical communication with the crystal generating electric
signals indicative of the light's source and intensity.
30 Cameras of this variety are generally referred to as an
"Anger" or gamma ray camera. U.S. Patent No. 3,011,057,
discloses such a device.

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When exposed to a radioactive source, a scintillation camera of this type produces an image of the isotope distribution by recording the phototube outputs corresponding to the incidence of individual gamma rays on the crystal. The phototube outputs are interpreted and translated by electronic circuitry into orthogonal (X, Y) spatial coordinates and a third signal (Z) representative of the energy level of each gamma ray event. The energy Z signal is particularly useful for screening or filtering out unwanted detections which result from background radiation, scattering, etc. By establishing an energy window around the energy level known to be typical of the nuclide sought to be detected the desired X, Y and Z signals may be accepted for processing while unwanted signals are rejected.

A well known problem of gamma cameras relates to the inherent nonlinearities of camera design and construction. The nonlinearities, which are exacerbated with attempts to increase camera resolution, result in spatial distortion of image points. This distortion results in both nonlinearity and nonuniformity of image. In general, nonlinearity may be attributed to (X,Y) signal distortion. Nonuniformities can arise either from these same distortions or from variance in Z signal response as a function of (X, Y) source position. These spatially related inherent sources of image distortion may be corrected in various ways. U.S. Patent No. 3,745,345, discloses one attempt to correct spatial non-linearities. However it has been found that the method disclosed therein creates further artifacts that distort the images. In our U.S. Patent Nos. 4,212,061 and 4,281,382 X and Y correction factors are derived and stored for employment in correcting camera signals on-line while the image is being acquired.

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As made clear by US. Patent Nos. 4,212,061 and 4,281,382, the differences in Z signal, as a function of the source position, are of significance in correcting distortion due to non-uniformity of image. Accordingly, the above-identified patents disclose a procedure or method of normalizing the camera Z response as a function of source position. The method, which is described in detail in the patents, involves acquiring a separate energy histogram for each unique (X, Y) element of the camera image. The elements are defined by a 64 x 64 matrix in apparent space i.e. the uncorrected (X,Y) camera response. The histogram includes the number of counts and their associated energy level for each element. A standard search and fitting routine may be applied to the accumulated data to determine the peak, about which a low Z threshold value and a high Z threshold value are determined to define a window. These values are placed in a Z translation table having unique threshold pairs for each of the apparent space 64 x 64 matrix elements. The nonuniform response of the camera to gamma ray energy levels may then be compensated for according to which element the event appears in. By controlling how the Z threshold window is defined, one is able to not only maximize the detection of significant information but minimize recording of unwanted events.

The above-described method provides effective means for accepting, according to the apparent element of origination, only those (X,Y) signals having energies which will contribute to the construction of a meaningful picture or image; the present invention extends and improves that method by modifying how the energy selection or window is determined.

Summary of the Invention

The present invention provides an improved apparatus and method for selecting only meaningful information from signals produced by suitable transducers

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and in particular Anger-type radioisotope cameras producing positional information. Specifically, the present invention is an improvement in the means for determining energy threshold values as a function of radiation event
5 positional information disclosed in U.S. Patent Nos. 4,212,061 and 4,281,382.

According to the invention, there is provided a method of calibrating a scintillation radiation camera to provide uniform energy level response at various spatial
10 elements of the camera face, comprising:

flooding the camera with a substantially uniform radiation; determining the apparent spatial position and energy level of detected radiation events;

determining corrected spatial positions of the
15 detected radiation events;

determining the energy level distribution of the detected radiation events in each of a plurality of uniform corrected spatial elements; and

determining an energy level acceptance window in
20 each distribution such that the number of events accepted in each element is substantially the same.

In the present invention, in one embodiment, the establishment of the energy threshold table begins by flooding the camera face with a uniform source of
25 radiation and utilizing the pre-established spatial

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translation table to reposition detected radiation events according to their true spatial element coordinates. A histogram is compiled for each true spatial element, the histogram comprising the number of radiation events occurring at a plurality of discrete energy levels. A peak centroid value is then determined for each element, and an initial energy window is set. Next, a specified region of the camera field of view, usually the center of the image, is inspected to determine a target sum of radiation events to be accepted by each element whereby a standard is set for adjusting the energy windows of each element. Using the standard, the energy window for each element is progressively adapted so that every element will accept nearly the same number of radiation events or counts in response to a flood or calibration image. Finally, the energy window for each true spatial element is translated back to its apparent spatial element and incorporated into an energy threshold table accessible by the apparent spatial coordinates of each radiation event. The energy windows thus established and incorporated into a radiation signal processing system of the type disclosed in U.S. Patent Nos. 4,212,061 and 4,281,382 provide for greater uniformity of image than previously achievable.

It should be clear that the invention is not dependent on the particular numbers used to define the true space, that is, any corrected coordinate system that

differs from the true space coordinate system by a predetermined value or values is equivalent to the true space coordinate system, since the difference can be accounted for at any point in the correction process simply by
5 adding or subtracting the known predetermined value or values to the coordinate system. Thus although for ease of understanding, the (U,V) space is referred to as "true" space or similar terminology, it is understood that corrected space using corrected coordinates can also be used
10 in the invention. In this specification "corrected" and "true" will be used interchangeably. The term "true" is used for ease of understanding however the broader concept "corrected" is intended.

The foregoing method provides improved imaging
15 capability by eliminating to a great degree nonuniformities due to spatial variation in the camera energy level detection response.

Other objects and aspects of the invention will become clear upon consideration of the detailed description
20 of an illustrative example of the invention in conjunction with the drawings.

Brief Description of the Drawings

Figure 1 is a functional block diagram for the system of the present invention;

25 Figure 2 is a schematic representation of three matrix arrays for the X, Y and Z correction values;

Figure 3 is a diagrammatic representation of an idealized special correction as may be used in the present invention;

30 Figure 4 is a typical energy histogram for a radiation transducer;

Figure 5 is a diagrammatic representation of an energy histogram for an element of a flooded image in true space compared to the prior art correction technique
35 in apparent space; and

Figure 6 is a plan view of a calibration plate.

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Detailed Description of the Preferred Embodiment

To facilitate the understanding of the present invention a brief review of the methods and apparatus disclosed in U.S. Patents 4,281,382 and 4,212,061, herein-
5 after referred to as the prior system, will be given.

Referring to Figure 1, which assumes intercon-
nection with a computer, the radiation imaging apparatus
of the prior system is depicted in functional block dia-
grammatical form. Transducer 11 is a gamma camera similar
10 to that described in U.S. Patent No. 3,011,057 and detects
radiation events emanating from an external source. Camera
output signal 12 is operated on by camera electronics 13
to provide orthogonal spatial coordinates X 14 and Y 15
and energy signal Z 16. These analog signals are then
15 digitized in analog to digital converter 17 producing
preferably twelve (12) bit X and Y words 18, 19 re-
spectively, and preferably an eight (8) bit Z signal 20. The
12 bit X and Y words are comprised of 6 MSB's (most
significant bits) defining the element of origin in a
20 64 X 64 matrix and 6 LSB's (least significant bits) de-
fining the precise location within the element for each
detected event.

Coordinate signals (X, Y) are corrected to their
corrected or true coordinate U (27) and V (28) values re-
15 spectively (or any equivalent space, such as any space
differing from the true space by a predetermined value or
values) by accessing translation table 23, with the 6
MSB's of the (X, Y) signals. Table 23 comprises linear
rectangular matrix arrays containing U,V values addressed
20 by their respective corresponding X, Y coordinates and
interpolation routines are performed in arithmetic unit 24
with respect to the 6 LSB's of the (X, Y) signals. Pro-
cessor signals 25, 26 represent information going into and
out of arithmetic unit 24 during the performance of
5 specifically called up routines. Translation table 23
also furnishes a pair of selected energy threshold signals



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Z_t 21 for the particular apparent (X, Y) coordinates of detected radiation events. The energy level of Z signal 20 is compared with the Z_t signals 21 in comparator 22 and if found within the appropriate range, i.e. between acceptable window limits, gate signal Z' (Z prime) is generated and gate 30 allows each acceptable energy event to be recorded and displayed at corrected coordinates (U, V).

The calibration procedure used in both the prior system and the present invention which is required to furnish the spatial coordinate correction data may be summarized as follows. A precision grid, for example the one shown in FIGURE 6, is positioned over the camera face and the camera then subjected to a source of radiation positioned effectively at infinity. Grid 50 has approximately 18 to 20 lines or gaps 52 formed therein, each line having dimensions selected so that its apparent width is determined primarily by the spatial resolution of the camera, viz, a width of approximately 3 mm and center to center spacing of approximately 15 mm. As described in the patents corresponding to the prior system this provides a known image to the camera scintillation crystal, whereby any deviation or distortion in camera spatial (X, Y) response may be determined. With grid 50 positioned over the camera face so that image lines (52) 1 to n are in a substantially vertical orientation, a pair of ADC (analog to digital converter) values (X_n , Y_i) corresponding to one of 64 equally spaced orthogonal profiles or Y positions is selected for determination of a corresponding entry in the spatial correction tables. Events are detected at each of the X_n image lines corresponding to profile Y_i , and data representing a one dimensional profile through the image with event peaks at each line is generated. The centroid X_c of each peak is then determined. This provides X_c values for the uniformly spaced known U values of the calibration image. This data is

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then spline fit to derive a relation of $U = ax^3 + bx^2 + cx + d$. Based on this relationship, U values for preferably 64 predetermined X coordinates are determined. In the same manner relationships are derived for preferably 64 values of Y_i . The entire procedure is then repeated, after rotating grid 50 by 90° , to derive a best fit expression of $V = ey^3 + fy^2 + gy + h$ for all 64 values of X_i and then the entire spatial corrective data is entered into the translation tables i.e. U and V values as functions of 64 X, Y coordinate locations in the rectangular matrix arrays.

FIGURE 2 is a graphical representation of the translation tables. Digitized apparent space coordinates X and Y are input to translation tables 31, 32 producing true spatial coordinates (U, V). With reference to FIGURE 3, the 6 MSBs of the digitized X and Y analog coordinates are used to access translation tables 31, 32 obtaining the corresponding true (U, V) coordinates (6 MSB precision) for such position and for each next higher coordinate $(X, Y)_{2-4}$ position in the 64×64 matrices. The translation of these coordinates from an uncorrected (X, Y) mapping to true coordinates (U, V) mapping is shown in solid outline. If succeeding translated corrected elements of the image events were shown they would form a contiguous mosaic without overlapping or voids.

Upon determination of the 6 MSB precision (U, V) corner coordinates of the translated (X, Y) element and assuming a linear relationship in the intervals, a linear proportional interpolation is performed using the 6 LSBs of each X and Y coordinate to find "precise" corrected spatial (U, V) coordinates corresponding to the (X, Y) apparent spatial coordinates of the detected events occurring intermediate or within the translated element area. The procedure involves assuming a linear relationship in both dimensions of the precise location of the detected (X, Y) event within the corrected area defined by

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(U, V)₁₋₄. Given this assumption, X (Δx) and Y (Δy) increments are determined and used to precisely locate the apparent event in true space. In this manner there is effectively achieved the precision of correction associated with a 4096 x 4096 translation table with the economy and ease of calibration associated with a 64 x 64 matrix.

As pointed out above, camera Z signal response variation is important from a number of aspects. If a fixed acceptance window is used to select only radiation events of interest, nonuniformity of the image will result from this variation. The prior system corrects most nonuniformity due to Z signal variations by independently presetting the Z_t energy thresholds or "window" for each camera face element of the 64 x 64 matrix. A typical energy histogram 80 for a gamma camera is shown in FIGURE 4. Under normal circumstances, only the peak energy content of the incident radiation is of interest. Therefore, the energy window 81 is selected so that only peak events are recorded. This is accomplished by rejecting all events not displaying a Z level between the upper and lower threshold values of the Z window.

The prior system began normalization of Z camera response by flooding the camera face with a stationary calibration point source so that all areas received energetic events of known intensity. A separate energy histogram or spectrum 80 was acquired for each unique 6 MSB (X, Y) apparent space element of the 64 x 64 matrix array translation table 33 of FIGURE 2. In essence, camera responses were sorted by spatial (X, Y) coordinates and by Z signal energy level 82 (the analog energy level is digitized and sorted according to its magnitude in 32 levels, which are also referred to as channels), each level having an event count N_i associated therewith. Using standard peak search and fitting routines on the data accumulated in the histogram a 16 bit word was developed

for each element, 8 bits setting the lower Z_t value and the remaining 8 bits setting the higher Z_t value. Once set these values were placed in the Z translation table and accessed by the MSBs of each event. Thereafter, during the camera imaging process (X,Y) events were accepted or rejected according to the predetermined energy window of the matrix element in which they originate.

Thus, the prior system normalized Z signal response by varying the profile of acceptable Z signal energy levels with respect to the apparent space elements defined by the (X,Y) spatial coordinates. The result was a more uniform image response to a flood signal than possible using only spatial corrections.

Although the Z signal normalization procedure of the prior system provides means for the correction of most of the nonuniformity of response due to spatial dependency of Z signal response, it has been observed that there are still some errors in imaging the crystal that are not accounted for. It has been determined that some of these errors are attributable to imperfections in the definition of the acceptable Z window for each element. That determination begins with the following observation of the operation of the prior system: if the camera scintillation crystal is divided into e.g. 64 x 64 equal elements and a uniform gamma source is applied to the crystal, then when each of the equal areas in apparent space (X, Y) is mapped to an area in corrected or true space (U, V), then each of the areas in (U, V) space should receive an equal number of counts if the correction to (U, V) space was perfect. On the contrary, in practice it is found that the numbers of counts in each equal section of (U, V) space are not the same. It has been determined that this non-uniformity is due in part to imperfections in the translation table introduced by spatial distortion not completely eliminated during calibration, in part to in-

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trinsic nonuniformity of the camera response, in part to imperfections in the calibration grid, and in part to the limited precision of the mathematical computations.

With these observations in mind, the present invention begins the energy calibration procedure by sorting the multi-channel energy spectra into uniform elements in true (U, V) space. This is in contrast to the prior system in which the energy spectra were sorted into elements in apparent (X, Y) space. Referring to FIGURE 5 this difference is graphically illustrated. Energy spectrum 70 corresponds to element 72 ($X = 63$, $Y = 0$) of apparent (X, Y) space. In the prior system similar spectra were acquired for all 64 X 64 matrix elements. The present invention acquires similar spectra but, each of the spectra correspond to corrected (U, V) elements. For example, spectrum 74 corresponds to corrected element 76, which is generally equivalent to element 78 ($X = 0$, $Y = 0$) of apparent space. The same fitting procedures of the prior system are applied to find the centroid X_c and width of the photopeak, to determine the peak energy content of interest, in each of these corrected space spectra. An initial energy window for each of these (U, V) elements is then specified by the user. The energy window is specified by setting a quantity of standard deviations either side of the centroid X_c . It will be understood that while in the present invention it is preferable to find, to the greatest practicable degree, the precise centroid X_c of the photopeak, other schemes finding only an approximate centroid X_c could be utilized.

Because of the sources of imperfections noted above, the number of recorded counts occurring within each window determined for each (U, V) element in the camera field of view still may not be completely uniform, i.e. certain elements accept more events than others even though all are exposed to a uniform flood signal. Therefore, the present invention provides an adapting step that

changes the energy window for each (U, V) element to achieve a condition in which all will incorporate nearly the same number of recorded counts.

The adapting step first determines a target sum to which the counts within each window will be adapted. This target sum (typically an average) is established by inspecting the counts accepted in each true (U, V) element over a selected region of the camera field of view (typically the center portion). Once this target sum has been determined, the window edges or thresholds 81 for each individual (U,V) element are progressively adapted (either shifted, widened or narrowed) until the counts contained within that element are as close as possible to the target sum. These adapted window edges 83 are then incorporated into a Z signal energy translation table by mapping the true (U, V) elements and their corresponding Z_t values back into apparent (X, Y) space using the spatial translation table. The newly defined Z_t values may then be accessed directly by the camera's digitized (X, Y) coordinates without resort to the spatial translation table, thus simplifying the hardware structure and improving the signal processing speed.

To summarize one embodiment of the new method of the present invention for determining the Z translation table:

1. Events are detected by the camera, digitized, and translated from apparent (X,Y) to true or corrected (U,V) space.
2. Each event is sorted according to energy level and (U, V) element location.
3. Photopeaks are determined using the calculated centroid X_c values.

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4. Initial Z signal window thresholds Z_t are selected.
5. A target sum is determined by inspecting counts in a specified region of the camera field of view, usually the center of the image.
6. Z window thresholds Z_t for all 64 x 64 (U, V) matrix elements are progressively adapted until counts are nearly equal to the target sum in all elements.
- 10 7. The Z signal window threshold pairs for each (U,V) space element are incorporated into the Z signal table by mapping backwards to apparent (X, Y) space.

15 It will be seen from the foregoing that the present invention achieves more uniform flood images from radioisotope cameras, allows removal of artifacts in the image created by high-frequency spatial distortion that may not have been completely removed by the prior system, and that the present invention will allow design of gamma
20 cameras to optimize other parameters, such as spatial resolution, at the expense of spatial linearity to an extent not now permitted. In addition, it shall be understood that the present invention may be practised in other ways than set forth in the preferred embodiment.
25 For example, the adapting step may be utilized whether or not the histograms are compiled with respect to true or corrected spatial elements, and the translating step providing histograms corresponding to true spatial elements may be utilized without the adapting step.

Claims

1. A method of calibrating a scintillation radiation camera to provide uniform energy level response at various spatial elements of the camera face, comprising:

5 flooding the camera with a substantially uniform radiation;

determining the apparent spatial position and energy level of detected radiation events;

determining corrected spatial positions of the detected radiation events;

10 determining the energy level distribution of the detected radiation events in each of a plurality of uniform corrected spatial elements; and

determining an energy level acceptance window in each distribution such that the number of events accepted
15 in each element is substantially the same.

2. A method as claimed in claim 1 further comprising converting the corrected spatial positions of the elements to apparent spatial positions and storing the energy level
20 window values so as to be accessible by the apparent positions of detected radiation events.

3. A method as claimed in claim 1 or 2 wherein the step of determining the energy level distributions comprises
25 determining an energy histogram by counting the radiation events at each of a plurality of discrete energy levels within each corrected spatial element.

4. A method as claimed in claim 3 comprising determin-
30 ing the peak centroid of each histogram;

defining an energy window about the peak centroid for at least one element to set a standard number of acceptable energy events for all the elements; and

35 adapting the energy window of each remaining element to cause each element to accept a count of radiation events substantially equal to the standard.

5. A method as claimed in claim 4 wherein the adapting step includes determining for each element whether the window must be widened or narrowed and then progressively adjusting the window in the appropriate direction.

5 6. Radiation imaging apparatus comprising:

(a) detector means capable of producing an output signal representing the corrected orthogonal spatial coordinates and energy level of a radiation event;

10 (b) means for determining the energy level distribution of corrected radiation events within each of a plurality of corrected spatial elements; and

(c) means for determining for each of said elements the energy window to be accepted in response to a flood image such that every element accepts substantially the same number of events.

7. Apparatus as claimed in claim 6 wherein the detector means comprises means capable of producing an output signal representing apparent orthogonal spatial position coordinates and the associated energy level for each detected radiation event and means for translating detected events from their apparent spatial position to a corrected spatial position.

8. Apparatus as claimed in claim 6 or 7 wherein the means for determining the energy level distribution comprises means for obtaining a histogram of detected radiation events for each corrected spatial element in response to a flood image of known energy level.

9. Apparatus as claimed in claim 8 wherein the means for determining the energy windows comprises means for determining the point about which a photopeak is generally centered of each said histogram; means for defining an energy window about said point for at least one element to set a standard number of acceptable radiation events for the elements; and

means for adapting the energy windows of the elements to cause each element to accept a count of radiation events substantially equal to the standard.

10. An improved signal processing system including
5 improved calibration apparatus for use with a radiation imaging apparatus, comprising:

(a) a radiation transducer for producing signals representative of the apparent orthogonal spatial coordinates and of the energy level of detected radiation
10 events;

(b) means operative in a spatial calibration mode for storing corrected spatial coordinates corresponding to a plurality of predetermined apparent spatial coordinates relative to selected detected
15 radiation events;

(c) means for translating apparent spatial coordinates to corrected spatial coordinates, said translating means communicating with said means for storing;

20 (d) means for interpolating the corrected spatial coordinates of the detected radiation events occurring within the space bounded by said stored corrected spatial coordinates to produce precise corrected spatial coordinates;

25 (e) means operative in an energy level calibration mode using coordinates derived from said translating means for obtaining a histogram for each corrected spatial element;

(f) means operative in said energy level
30 calibration mode for setting a window of acceptable energy levels;

(g) means operative in said energy level calibration mode for determining the number of counts in response to a flood image occurring within said window for each corrected spatial element;

(h) means operative in said energy level calibration mode for progressively adapting the window for each element until all of said elements accept substantially the same number of counts in response to the flood image;

5 (i) means operative in said energy level calibration mode for storing one or more of said windows as a function of apparent spatial coordinates;

(j) means for comparing the energy level of the transducer signals of the detected radiation events to the
10 windows corresponding to the apparent spatial coordinates of the events; and

(k) output means for producing an output signal, said output means being responsive to said transducer signals and to said comparing means so that only those
15 transducer signals occurring within the windows contribute to form said output signal.

11. A method for calibrating a scintillation radiation camera to provide uniform energy level response to detected radiation events comprising the steps of:

20 (a) flooding the camera with a known uniform radiation energy;

(b) accumulating the histograms of the detected radiation events as a function of predetermined corrected spatial coordinate position and energy level;

25 (c) inspecting at least one histogram to set a standard number of acceptable energy events; and

(d) determining an energy window for each histogram to cause each energy window to include a count of radiation events substantially equal to the standard.

12. A method for calibrating a scintillation radiation camera to provide uniform energy level response at various elements comprising the steps of:

5 (a) flooding the camera with a known radiation energy;

(b) counting the radiation events detected at each energy level within the elements to produce a representation of energy level distribution;

10 (c) determining the point about which the photopeak is generally centered for the distribution for each element;

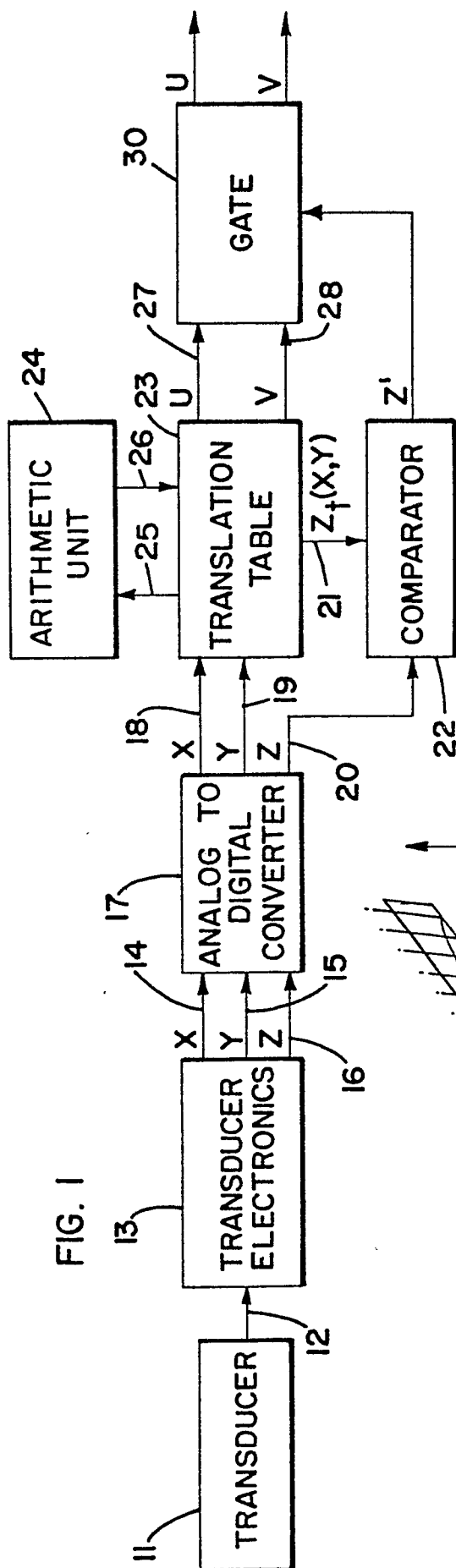
(d) defining an energy window about said point for one or more elements to set a standard count of acceptable radiation events for all elements; and

15 (e) adapting the energy window of each of the elements to cause each to accept a count of radiation events substantially equal to the standard.

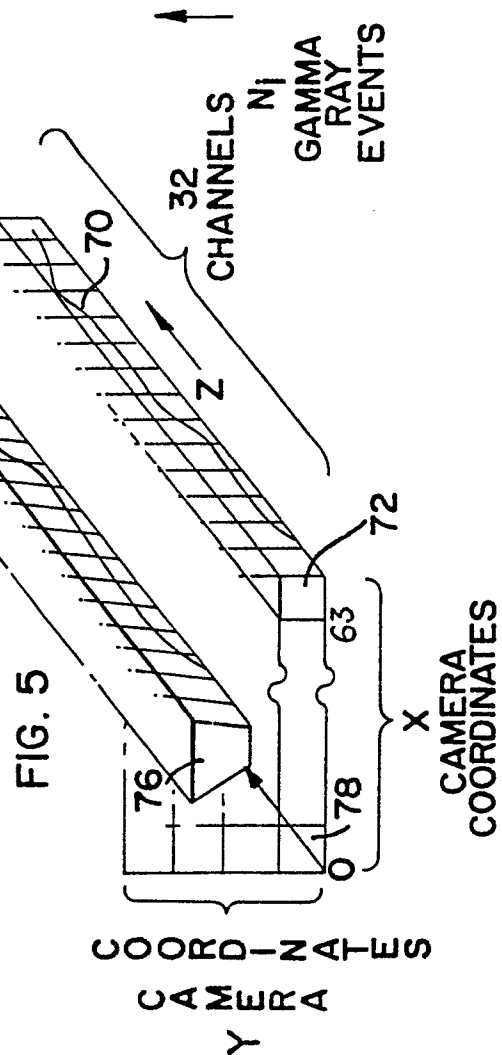
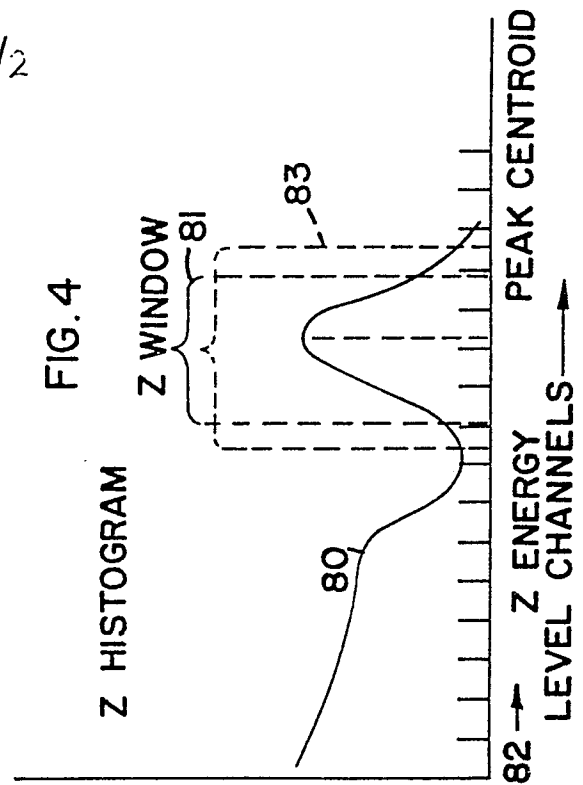
13. A signal processing system for use with a radiation imaging apparatus having detector means for producing an output signal representing apparent orthogonal spatial coordinates and the associated energy level of a radiation event, comprising:

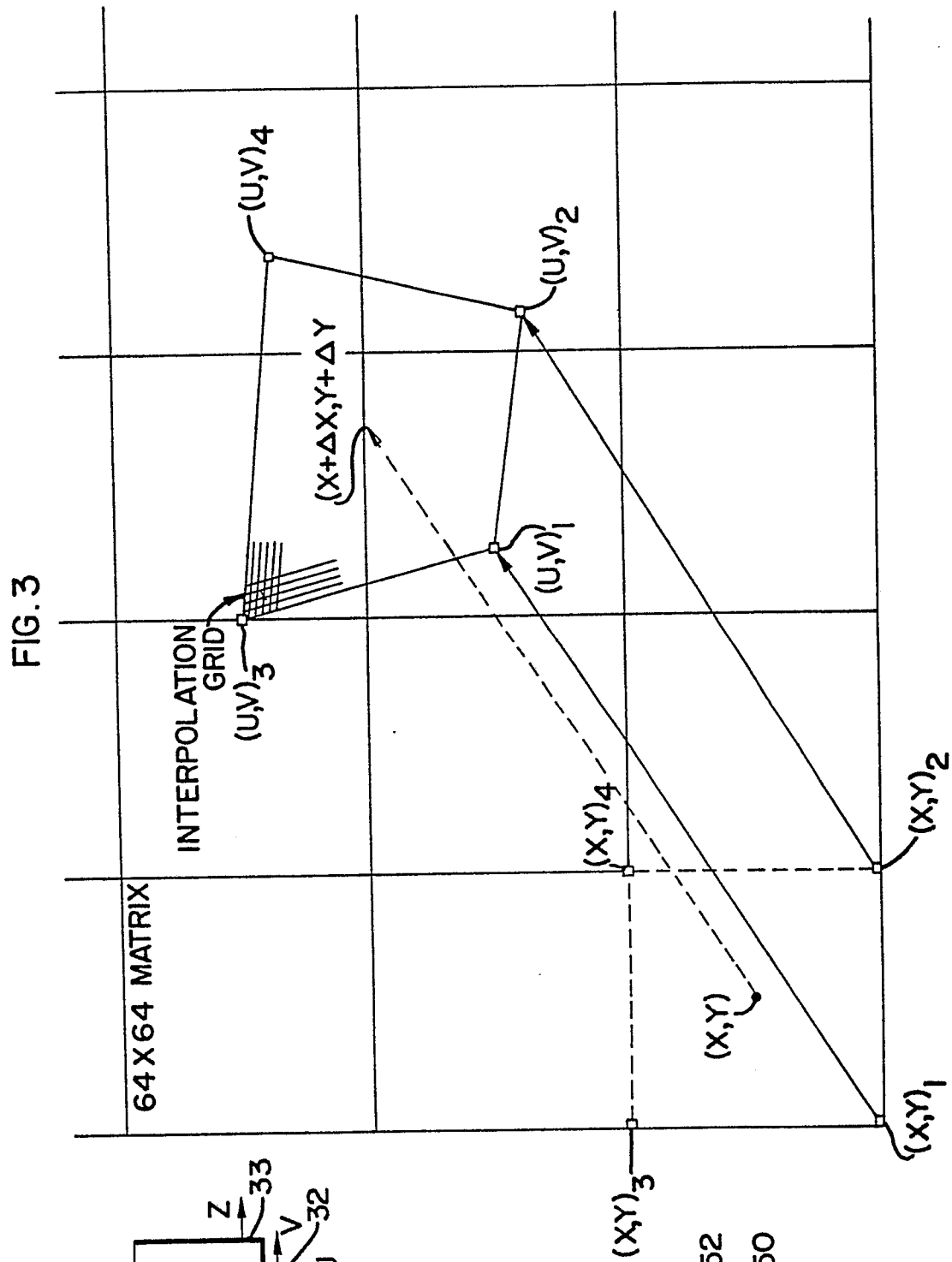
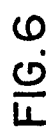
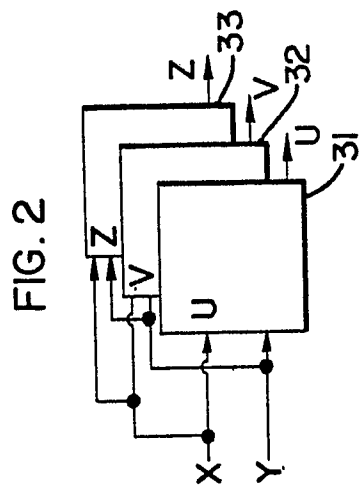
20 means for determining the energy level distribution and peak energy content of radiation events occurring within predetermined elements in response to an image of known energy level, each of said elements being defined as a predetermined portion of the apparent image field; and

25 means for determining an energy window to be accepted for each element in response to a flood image such that every element accepts substantially the same number of events in response to a flood image.



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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	JOURNAL OF NUCLEAR MEDICINE, vol. 19, no. 6, June 1978, page 712, New York, USA J.W. STEIDLEY et al.: "Uniform- ity correction with the micro Z processor" * Whole article *	1	
A	--- US-A-4 095 108 (DAN INBAR et al.) * Abstract; column 2, lines 27-61; column 3, line 56 - column 6, line 27; figures 1-6 *	1, 5, 6, 9	
A	--- JOURNAL OF NUCLEAR MEDICINE, vol. 21, no. 8, August 1980, pages 771-776, New York, USA G. MUEHLLEHNER et al.: "Cor- rection for field nonuniformity in scintillation cameras through removal of spatial distortion" * Page 771 - page 773, left-hand column, line 12; page 775, left-hand column, line 19 - page 776 end of summary; figures 1,2,4 *	1, 10	
P	--- IEEE TRANSACTIONS ON NUCLEAR SCIENCE, vol. NS-29, no. 4, August 1982, pages 1272-1279, IEEE, New York, USA G.F. KNOLL et al.: "Computer cor- rection of camera nonidealities in gamma ray imaging" * Whole article *	1-13	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 15-07-1983	Examiner DATTA S.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EUROPEAN SEARCH REPORT

Application number

EP 83 30 2051

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	EP-A-0 007 698 (PICKER CORP.) * Abstract; page 2, line 5 - page 3, line 17; page 4, line 27 - page 7, line 22; page 7, line 29 - page 12, line 29; claims 1-3; figures 1,2 *	1,2,4- 7,9,10 ,12,13	G 01 T 1/164
D,Y	--- EP-A-0 002 540 (MEDTRONIC INC.) * Abstract; page 2, lines 3-31; page 3, lines 30-37; page 4, line 13 - page 5, line 12; page 6, line 16 - page 7, line 35; page 9, line 31 - page 11, line 2; page 12, line 9 - page 14, line 16; figures 1-11 *	1-4,7, 8,10- 13	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	--- JOURNAL OF NUCLEAR MEDICINE, vol. 19, no. 6, June 1978, page 746, New York, USA G.F. KNOLL et al.: "Real-time correction of radioisotope camera signals for nonuniformity and nonlinearity" * Whole article * --- -/-	1,5,6, 11	G 01 T
The present search report has been drawn up for all claims			
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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			